TECHNICAL REPORT NO. 72-07

SIGNIFICANCE OF DETECTOR SENSITIVITY IN DETECTION OF DRUG ABUSERS

Final Report

By

Donald O. Egner
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Research Analysis Office

September 1972

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

U. S. ARMY LAND WARFARE LABORATORY
Aberdeen Proving Ground, Maryland 21005

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ABSTRACT

To gain an understanding of the relationship of drug detector sensitivity to the actual detection of drug abusers, those parameters which are considered of prime importance in determining the probability of detecting drug abusers have been examined. In addition, attempts have been made to quantify the important relations of drug concentration in urine to elapsed time after drug administration and elapsed time after urination.

FOREWORD

Numerous techniques for the detection of drug abusers have been investigated by LWL and other laboratories. Research on these techniques usually leads to a stated requirement for greater sensitivity while minimizing false predictions. The objective of maximizing probability of detection is often lost in the search for increased sensitivity. Keeping the ability of detection as its foremost objective, this study utilizes data collected by Lemberger, Axelrod, and Kopin*, of the National Institute of Health, to investigate selected parameters judged to be prime contributors to detection probability. In addition, an attempt is made in this study to quantify the important relations of drug concentration in urine as a function of time.

The primary conclusion of this report is supported by the mathematical exercise undertaken; thus, some of the detailed support of generalized statements has been omitted for the sake of brevity.

*Lemberger, L., Axelrod, J., Kopin, J., "Metabolism and Disposition of Tetrahydrocannabinols in Naive Subjects and Chronic Marijuana Users," Annals of the New York Academy of Sciences, Vol 101, 31 Dec 71.

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INTRODUCTION

There are at present certain techniques either in existence or under development for the detection of drug abusers. While there is a continuous effort to increase the sensitivity of these techniques, there is scant evidence of efforts being made to gain an understanding of the relationship of sensitivity to the prime objective of detectability, viz., the detection of drug abusers. The purpose of this report is to examine this relationship independent of the detection technique. In essence, the operational application of detection techniques is as significant as the techniques themselves.

DISCUSSION

One of the first problems encountered in a study of this type is the lack of information on the concentration levels of the drug in the sample to be tested (in this case, urine) as a function of time. As a first approach and in order to support the development of a detection technique model, the concentration of free morphine in the urine was postulated. The only available information at the initiation of this study was of a qualitative nature. It was stated by several eminent toxicologists in the field that the maximum concentrations of free morphine in the urine would occur around four hours after injection and that after eight hours less than 1/3 of the maximum concentration would remain.

As a first attempt to express in a mathematical form the concentration of administered material in the urine as a function of time and not knowing the actual distribution function, three mathematical types of distributions were considered. These were derived from other metabolic processes which are known, viz., distribution of blood glucose as a function of time following the oral administration of glucose to diabetics, to normal patients, and to those afflicted with hyperinsulinism*. These distributions were fitted with the constraint that maximum concentration of the drug in urine occurs around four hours after injection. It was realized that probably none of these distributions would exactly simulate the conditions under study; however, the impact of functional form on the ultimate detection probability was of interest. The functional relationships examined were:

a. Diabetic: $f(t) = 0.11t^2 e^{-0.5t}$

b. Normal: $f(t) = 0.08t^{5.6} e^{-1.4t}$

c. Hyperinsulinism: $f(t) = 0.26t^{1.6} e^{-0.4t}$,

where t is elapsed time (in hours) following administration of the drug. Based on these considerations, it was concluded that the functional form was not a critical parameter in determining the over-all probability of detection. Initial dose, of course, is critical.

*Langley, L. L., Review of Physiology, 3d edition, McGraw-Hill, New York, 1971, page 622.

This preliminary effort led to the development of a mathematical model, which together with some useful data collected by Lemberger, Axelrod and Kopin* of the National Institute of Health, allows one to examine the over-all process of drug abuser detection by urinalysis techniques. Lemberger, et al., obtained their data from experiments utilizing naive and chronic marijuana users. The basic data was generated by injecting 0.5mg Δ^9-THC into the subjects and measuring as a function of elapsed time after injection the percentage of administered dose found in the urine. The observations have been fitted by the following modified gamma probability density functions, where t is the elapsed time (in hours) following Δ^9-THC injection:

a. Naive Subject: $f(t) = 0.0056t^{1.4}\, e^{-t/6}$

b. Chronic User: $f(t) = 0.0056t^{1.5}\, e^{-t/7}$.

While these fitted functions are specific to marijuana users, they could possibly simulate the probability density functions to be expected for free morphine in the urine of heroin users. Consequently, plots of these fitted probability density functions, scaled to a more meaningful administered dose of 5mg, are shown in Figures 1 and 2 for both naive and chronic heroin users, respectively.

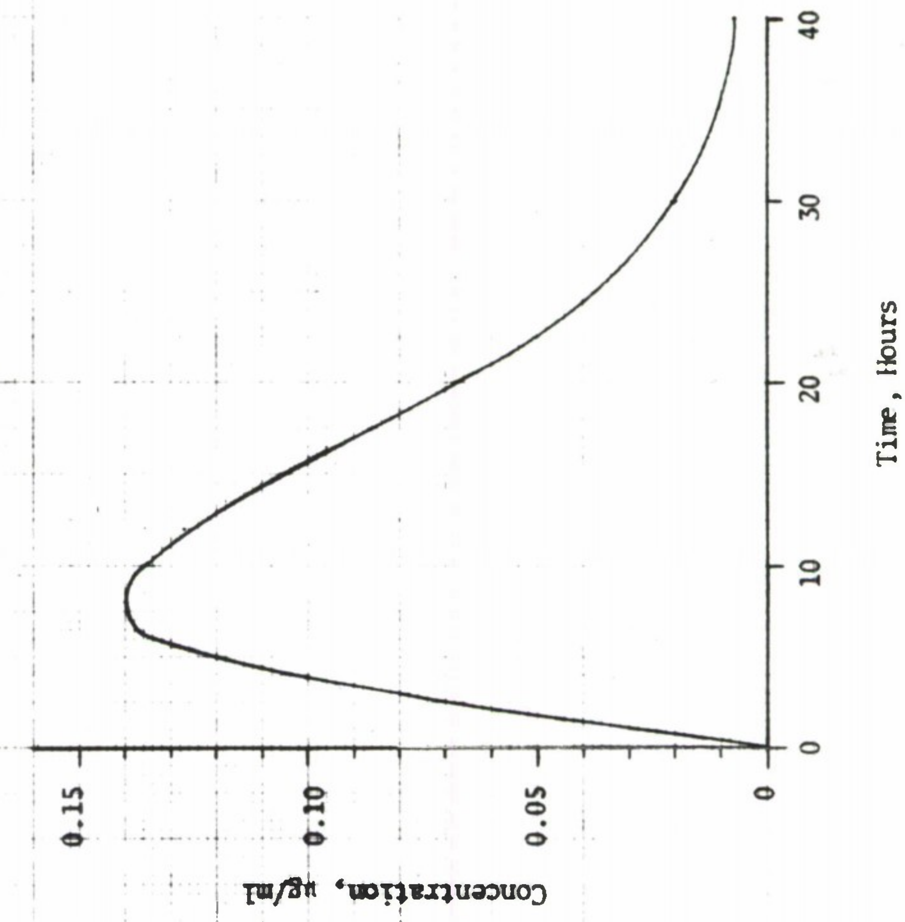
The basic model to determine detectability is a simple, probabilistic model, the probability of detection being directly computable by the determination of the time at which the concentration within the urine would be above the sensitivity level of the detector. It is recognized that the volume of urine collected will vary with frequency of urination and other factors; however, to demonstrate the model, a volume of 250cc was assumed for each collection irrespective of elapsed time since previous urination and the other factors. The final computational and assumptive problem deals with the integration of the probability distributions for the chronic user, since he is in essence continuously reinforcing his drug input. For purposes of this study, it was assumed that he received a 5mg injection of heroin every eight hours.

RESULTS

For a given dose intake level, free morphine concentration in urine is not only a function of elapsed time after dose intake but also of elapsed time since urination. The derived density function assumed to describe the concentration-time history distribution for the naive subject (Figure 1) was used to estimate the free morphine concentration in the urine of a naive subject, as a function of elapsed time after administration of a 5mg dose, for discrete elapsed times after urination; these results are shown in Figure 3.

*Lemberger, L., Axelrod, J., Kopin, J., "Metabolism and Disposition of Tetrahydrocannabinols in Naive Subjects and Chronic Marijuana Users," Annals of the New York Academy of Sciences, Vol 101, 31 Dec 71.

FIGURE 1



FREE MORPHINE CONCENTRATION IN URINE OF NAIVE SUBJECT AS A FUNCTION OF ELAPSED TIME AFTER SINGLE INJECTION OF 5mg DOSE OF HEROIN

FIGURE 2

FREE MORPHINE CONCENTRATION IN URINE OF CHRONIC USER AS A FUNCTION OF ELAPSED TIME AFTER SINGLE INJECTION OF 5mg DOSE OF HEROIN

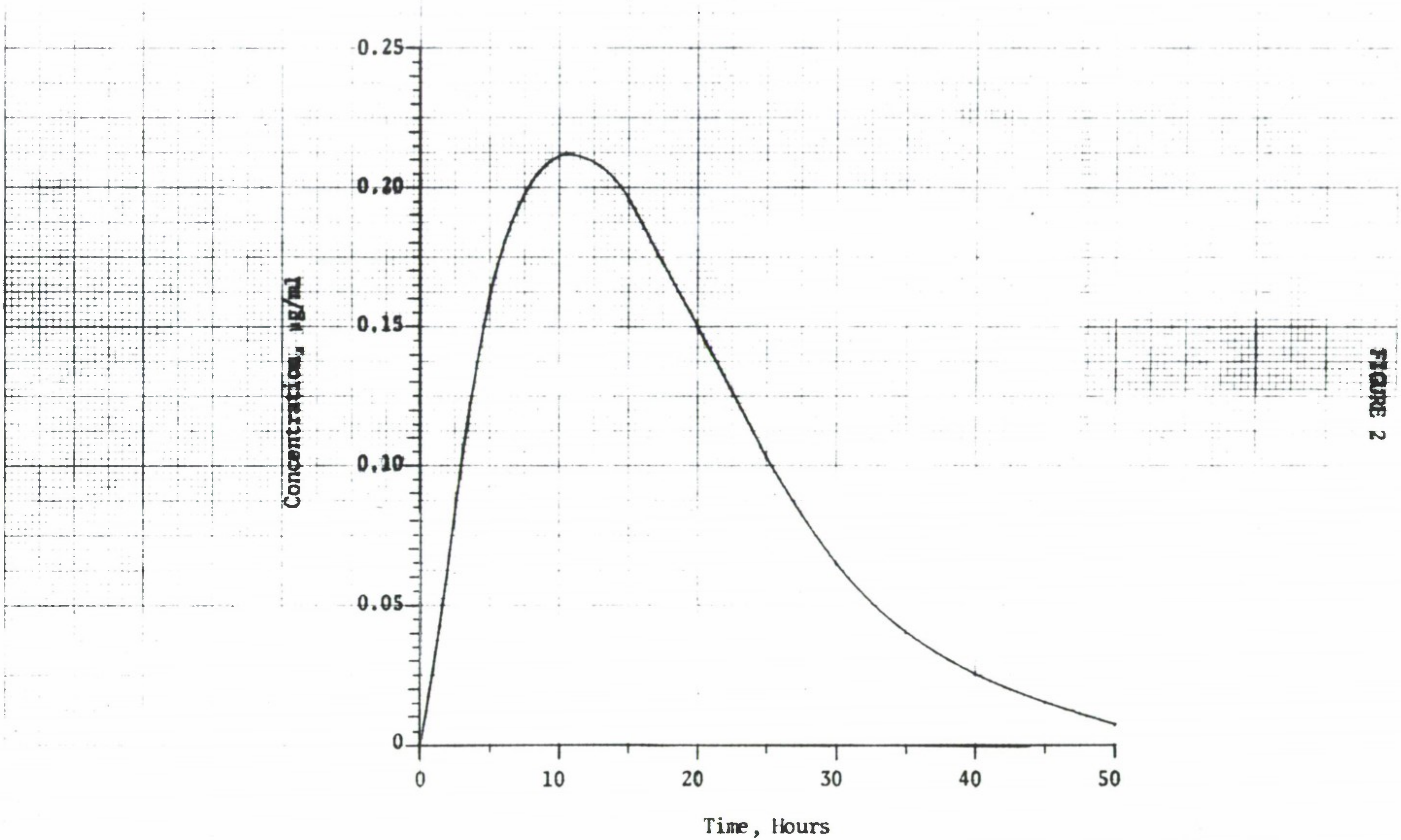
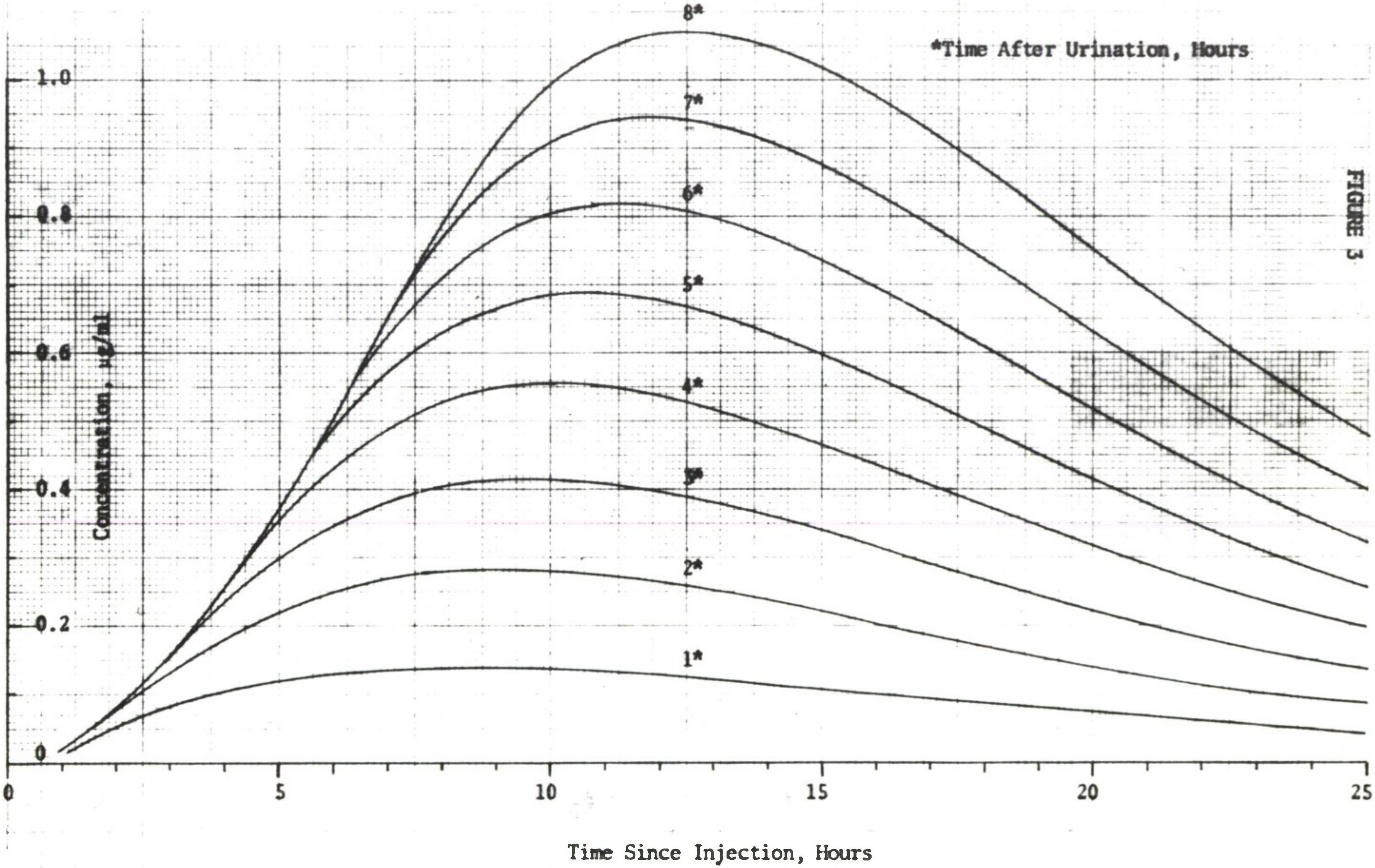


FIGURE 3

FREE MORPHINE CONCENTRATION IN URINE OF NAIVE SUBJECT AS A FUNCTION OF ELAPSED TIME AFTER 5mg DOSE OF HEROIN AND TIME AFTER URINATION



Assuming repeated administrations of 5mg doses every eight hours for the chronic user, the derived density function assumed for this subject (Figure 2) was used with a computer overlay technique to obtain estimates of free morphine concentrations in the urine as a function of time elapsed after dose administration and time elapsed after urination. As expected, the eventual effect of repeated administrations at eight-hour intervals is to produce a constant concentration for a given elapsed time between urinations; however, concentration increases with increasing time interval between urinations. Figure 4 is a plot of estimated free morphine concentration in the urine of a chronic user as a function of time after urination for a 5mg dose intake every eight hours.

The basic data of Figures 3 and 4 may now be utilized to predict the probability of detecting heroin abusers for selected detector sensitivity levels. Assuming some fairly realistic levels, sample probabilities of detection have been computed for both the naive subject and the chronic user (Table I).

CONCLUSIONS

Due to the generalized approach and underlying assumptions, this study is not recommended as a basis for the actual prediction of drug abuse detection probabilities; however, it is useful in determining the priority of effort for improving the detection of drug abusers.

It is apparent that research and development efforts directed solely to improvement of the sensitivity of a detection technique may be far less profitable than those directed at improvements in detector application. Specifically, although the basic concentrations indicated in the four figures (and the probabilities of the table) may be directly increased or decreased in proportion to dose intake, the over-all free morphine concentration level in the urine (particularly in the case of the naive subject) may be quite low. The lower this concentration level becomes, the lower the detector sensitivity level must be set to achieve detections and the greater the probability of false negatives (a fact clearly documented by tests of techniques which have been improved in sensitivity).

It is also apparent from this simplistic model that the probability of detecting a drug abuser can be improved by increasing the number of times a person is sampled and by clinical procedure, e.g., by shortening the time between samples and sampling promptly to avoid concentration loss due to presample urination.

Finally, it should be apparent that, like the surveillance/detection problem in general, drug abuse detection problems can best be approached by using a system of detectors which sample all reasonable indicators. The false negative problem can best be eliminated by such a system.

FIGURE 4

FREE MORPHINE CONCENTRATION IN URINE OF CHRONIC USER
AS A FUNCTION OF ELAPSED TIME AFTER URINATION
FOR 5mg DOSE OF HEROIN EVERY EIGHT HOURS

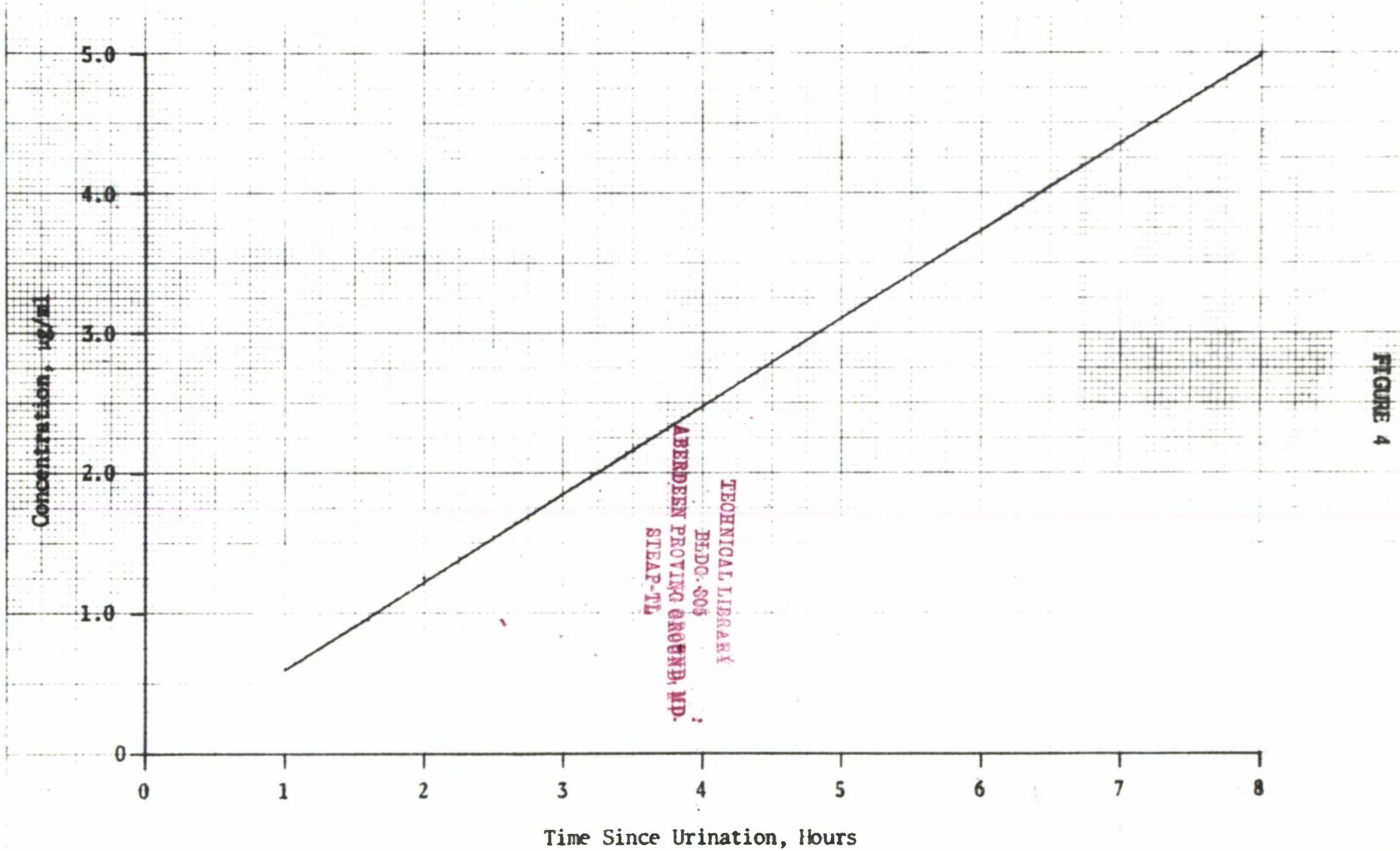


TABLE I

PROBABILITY OF DETECTING HEROIN ABUSERS BY A WEEKLY RANDOM SAMPLE OF URINE AS A FUNCTION OF DETECTOR SENSITIVITY LEVEL AND ELAPSED TIME SINCE LAST URINATION

Sensitivity Level of Detector, μg/ml	Naive Subject*			Chronic User**		
	Elapsed Time Since Last Urination, hrs					
	1	4	8	1	4	8
	Probability of Detection					
0.01	0.208	0.280	0.327	0.999	0.999	0.999
0.10	0.065	0.161	0.208	0.999	0.999	0.999
1.00	0	0	0.024	0	0.999	0.999

*Single dose of 5mg at t = 0
**Dose of 5mg every eight hours

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